Comparative Anatomical study on the Lower Respiratory Airway of Domestic Animals, Including Descriptive Anatomy of the Donkey's Trachea (A Model for Electronic Learning Module)

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Abstract:

In the last few decades, Egyptian higher education has faced many challenges, including a marked increase in students' numbers, insufficient necessary capabilities to develop educational processes, high costs of educational fees in private universities, and emergency circumstances especially during time of national crisis like the COVID-19 pandemic. Many educational institutions consider E-learning as a possible solution for many educational challenges via its advantages that not found in traditional teaching methods.

In response to such challenges, the present study, created electronic learning modules for teaching the donkey's trachea and comparative study of the bronchial trees in domestic animals.

To perform this study, the study was conducted on the lower respiratory system of ten donkeys of varying ages (3 to 5 years), as well as five sets of lungs and tracheas from buffalos, goats, camels and dogs. Theses specimen were subjected to variable anatomical techniques. For interactive and e-learning concepts, computer programs were used.

The present work concluded that the lower respiratory portions begins from the cricotracheal junction and the trachea of the donkey consists of 49-51 hyaline incomplete cartilaginous rings. The bronchial tree follows the lobation of the lung and each lobar bronchus supplied the corresponding lung lobe. Although great student's ratio was mostly satisfied with e-learning evaluation survey. However, noted technical issues with internet connectivity and IT facilities, so we recommended by using blended learning to overcome the cons of e learning.

Keywords: Gross anatomy, Domestic animals, Lower airway, E learning module.

Introduction:

The Egyptian higher education has encountered numerous challenges, including a significant surge in student enrollment, inadequate funding for educational programs, high tuition fees at private universities, and unexpected events such as the COVID-19 pandemic. To surmount these challenges, innovative and contemporary learning methods, particularly E-learning, have been deemed crucial, as they have been regarded globally as a potential solution to address educational issues during national crises. The E-learning overcome traditional education in several aspects, such as greater access, resource scalability, and the ability to learn at convenient times. It has also been shown to improve productivity, augment focus, and provide better academic results through audio-visual learning, coupled with variable media formats (***Nitin Sharma, 2023***). It is essential to evaluate the social, economic, and environmental impacts of e-learning implementation to ensure that e-learning programs are equitable, sustainable, and accessible in the long term ***Shakeel et al., 2023).***

The trachea is a long flexible extra pulmonary airway tube begins from the cricotracheal junction to the level of the fifth or sixth intercostal spaces where it divides into the right and left principal bronchi, each of which enters the corresponding pulmonary Hilus ***(Hare, 1975, Nickel et al., 1979, Singh et al., 2006, Konig et al., 2007, Dyce et al., 2018).***

The various lobes of Both the right and left lungs are ventilated by a corresponding lobar bronchus. ***(Nickle et al., 1979; Singh et al., 2006; Konig et al., 2007).*** The lungs receive their functional blood supply through the pulmonary trunk, which divides into two pulmonary arteries that follow the corresponding bronchus and continue through its branching. (***Osman and Ibrahim, 1981 in the donkey, Nakakuki, 2000*** in the horse.

The general aim of this study is providing E-learning modules as cutting-edge methods for teaching and learning veterinary anatomy.

The objectives of the current study are:

- Promote the inclusion of E-learning in all instruction and learning activities,
- Minimize learning expenses,
- Replace animal cadavers with expertly prepared specimens,
- Provide compensation for the reduced number of hours spent in direct instruction and the shortage of teachers,
- Enhance the efficacy and efficiency of the educational system, and
- Implement the findings of scientific research to enhance teaching methods.

Material and Methods

Animals: The study was conducted on the lower respiratory organs of ten seemingly healthy donkeys of varying ages (3 to 5 years), as well as five sets of lungs and tracheas from dogs that were acquired from the Department of Surgery after experimental research conducted by ***Ahmed et al. (2022).*** Additionally, five sets of lungs with intact tracheas of buffalos, goats, and camels were obtained from Cairo slaughterhouse. The donkeys were intravenous injected with 1.0 mg/kg bwt xylazine as sedative and analgesic (**Naglaa et al., 2015).** They were then properly bled through the common carotid artery and finally, embalming mixture containing (15%) formalin, (15%) glycerin, (5%) methanol, (10%) phenol, and (55%) water ***(Lynda, 2018)*** was injected into their system.

Techniques: The trachea and bronchial tree were subjected to the following techniques:

Descriptive gross anatomy:

The study involved examining the lower respiratory organs of the donkeys using preserved cadavers in the dissecting hall. Additionally, live specimens of other animals including buffalo, goat, camel, and dog were analyzed, focusing on the distinctive features of each animal's bronchial tree.

Radiography: The bronchial tree of different animals, as well as the pulmonary trunk, of the donkey, were radiographed using SIMENS MULTIX at K.V. 70 and M.A./S. 32, after filling with barium sulfate suspension ($BaSO_4$; M.W. 233.39; OXFORD LAB FINE CHEM LLP), through the trachea and injection of the pulmonary trunk of the donkey under suitable pressure.

Museum specimens were prepared according to El-Nady Technique ***(Elnady, 2016)***.

Cast modeling:

The bronchial tree was replicated using epoxy 150 colored with acrylic paint. It was then either manually dissected or immersed in HCL 33.5% (PGi CHEMICAS) to prepare a corrosive cast model.

The pulmonary trunk was studied after injection with gum milk latex colored red with carmine to pursue its ramification.

Developing E-learning modules:

The E-learning modules were developed according to ***(Fatma Elsaid et al, 2020),*** using scientific anatomical data which was categorized into two types. The first type was self-collected from the specimens studied in the present research. The second type was obtained by modifying some graphs from previous works, when necessary. It's important to note that the nomenclature used in all cases was according to ***NAV (2017) and Illustrated Veterinary Anatomical Nomenclature, 4th Edition (Gheorghe, 2019).***

Electronic tools:

- **Programs**: PPT, PS
- **Software's:** Artificial intelligence, TechSmith Camtasia 2019

• **Articulate Studio:** for Power Point
• **LMS** : Moodle learning platform
• **Hosting platform**: http://vetmed-academy.com

E-learning survey:
Was done, and statistically analyzed.

Results:

In all animals, including donkeys, the lower respiratory organs are comprised of two fundamental components - the conducting airway and the respiratory part. The conducting airway is made up of several parts, including the trachea, and its subsequent divisions. The respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli constitute the respiratory part which have a critical role in the gaseous exchange.

Trachea of the donkey (Figs.1&2):

The trachea of the donkey appeared lengthy, rigid, and flexible tube composed of 49-51 incomplete hyaline cartilaginous rings (***Cartilagines tracheales***). It extended along the ventral midline position through the neck region, and slightly pushed to the right about its termination. The tracheal tube began at the laryngeal-tracheal junction, at about the level of the 2nd cervical vertebra. It then crossed the base of the heart and run till the roots of the lungs, at about the level of the 5th rib. At this point, it bifurcates into the right and left primary bronchi.

The cervical part of the trachea ***(****Pars cervicalis****)*** is made up of 36-37 rings being extending from the crico-tracheal junction to the level of the 1st rib. The thoracic part ***(****Pars thoracica****)*** is made up of 13-14 rings, and extends from the level of the first rib to the level of the fifth rib.

The tracheal rings have dorsally-incomplete-c-shape, being compressed dorsoventrally. The two free ends of each tracheal ring are internally connected with smooth tracheal muscle *(Musculus trachealis)* and a dorsal tracheal membrane ***(****Paries membranaceus)*, while the series of tracheal rings are connected by fibro-elastic annular ligaments ***(****Ligg. Anularia trachealia)***. The Vagus nerves, common carotid arteries, jugular veins, and the recurrent laryngeal nerves accompany the cervical part of the trachea.

Bronchial tree *(Arbor bronchalis)*

General scheme:

The trachea connects the larynx to the root of the lung. The trachea is divided into two main bronchi (Bronchus principalis dexter et sinister), which enter the corresponding lung through the pulmonary Hilus. The right lung had four lobar bronchi (cranial, middle, caudal, and accessory) *(Bronchus lobaris cranialis, Bronchus lobaris medius, Bronchus lobaris accessories et Bronchus lobaris caudalis)*, while the left lung had three ones *(cranial, middle, and caudal).* Each lobar bronchus supplied the corresponding lung

lobe. The lobar bronchi (Bronchi lobares) are further divided into segmental bronchi *(Bronchi segmentales)* and subsegmental bronchi, bronchioles, and terminal bronchioles.

The respiratory portion of the bronchial tree comprised, respiratory bronchioles, alveolar ducts *(Ductuli alveolares),* alveoli *(Alveoli pulmonis),* and alveolar sacs *(Sacculi alveolares).*

The bronchial tree of the donkey (Figs.4, 5, 6, and 7)

The bronchial tree started at the level of the fifth rib, dorsal to the base of the heart, with the tracheal bifurcation, where the right and left principal bronchi were formed. Each principal bronchus gave rise to lobar bronchi which were named according to the lobes they supply.

The right principal bronchus directed caudolateraly to enter the right lung at its Hilus. From its lateral aspect, the right principal bronchus gave off an apical (cranial) lobar bronchus to supply the right apical lobe. Within this lobe, it gave off cranial and caudal segmental bronchi. In one case, both cranial and caudal segmental bronchi of the right cranial lobar bronchus were independently erupted from the main right principal bronchus (fig. 4/ 4,5).

The accessory lobar bronchus exited from the ventral aspect of the right principal bronchus beyond the origin of the middle bronchus. It supplied the accessory lobe through cranial and caudal segmental bronchi.

The right principal bronchus then continued as caudal lobar bronchus which supplied the right caudal lobe with 8-12 segmental bronchi that were directed laterally, medially, dorsally, ventrally, and caudally (fig. 4).

In four out of the examined donkey's lungs, the right lungs had right middle lobar bronchus branched from the ventrolateral aspect of the principal bronchus, 1cm caudal to the apical bronchus, supplying approximately the cranial third of the right caudal lobe and branching into cranial and caudal segmental bronchi (fig. 5/10).

The left principal bronchus gave off the left apical lobar bronchus to supply the left apical lobe and showed a similar pattern of division to the right one.

The left principal bronchus then continued as caudal lobar bronchus supplying the left caudal lobe through 8-12 segmental bronchi which were directed laterally, medially, dorsally, ventrally, and caudally in the vicinity of the left caudal lobe.

In four out of the examined donkey's lungs, a middle left lobar bronchus branched from the ventrolateral aspect of the principal bronchus supplying approximately the cranial third of the left caudal lobe and branching into cranial and caudal segmental bronchi (fig. 5/7).

Pulmonary trunk (*Truncus pulmonalis*) (Figs. 8, 9, & 10):

The pulmonary trunk originates at the Conus arteriosus, a section of the right ventricle of the heart, and divides into two branches: the right and left pulmonary arteries. These arterial branches enter their corresponding lungs in front of the tracheal bifurcation. The branches of the pulmonary arteries exhibit a behavior similar to that of the bronchial tree. (Fig. 9, & 10).

The right pulmonary artery (*A. pulmonalis dextra*):

The right pulmonary artery enters the right lung and branches into four parts: the right cranial lobar artery, right middle lobar artery, accessory lobar artery, and right caudal lobar artery. The right cranial lobar branch *(Ramus lobi cranialis)* originates from the ventrolateral part of the right pulmonary artery, just cranial to the origin of the right cranial lobar bronchus, and divides into cranial and caudal segmental branches. Similarly, the right middle lobar branch (Ramus lobi medii) branches off from the ventrolateral aspect of the right pulmonary artery, just cranial to the origin of the middle lobar bronchus, and also divides into cranial and caudal segmental branches. The accessory lobar branch *(Ramus lobi accessorii)* originates from the medial part of the right pulmonary artery, just cranial to the origin of the accessory lobar bronchus, and also divides into cranial and caudal segmental branches. Following the accessory lobar branch, the right pulmonary artery extends as the right caudal lobar branch (Ramus lobi caudalis), which further divides into 8 to 12 segmental branches extending in different directions: lateral, medial, dorsal, ventral, and caudal.

The left pulmonary artery (*A. pulmonalis sinistra*):

The pulmonary artery on the right side enters the right lung and divides into four branches: the right cranial lobar artery, right middle lobar artery, accessory lobar artery, and right caudal lobar artery. The right cranial lobar branch originates from the ventrolateral part of the right pulmonary artery before the beginning of the right cranial lobar bronchus. It then further divides into cranial and caudal segmental branches. On the left side, the pulmonary artery enters the left lung and divides into three branches: the left cranial lobar artery, the left middle lobar artery, and the left caudal lobar artery. The left cranial lobar branch bifurcates from the lateral aspect of the left pulmonary artery before the origin of the corresponding bronchus and subsequently branches into cranial and caudal segmental branches. The left middle lobar branch bifurcates from the ventrolateral aspect of the left pulmonary artery just before the origin of the middle lobar bronchus and similarly divides into cranial and caudal segmental branches. Lastly, the left caudal lobar branch represents the direct caudal continuation of the left pulmonary artery after giving off the left middle lobar artery. It further branches into

8-12 segmental branches that direct laterally, medially, dorsally, ventrally, and caudally.

The bronchial tree of the buffalo and goat (Fig.: 11, 12,13 &14)

The bronchial tree of both buffaloes (Figures 11 & 12) and goats (Figures 13 & 14) features a tracheal bronchus (Bronchus trachealis) that branches off about 9-11 cm before the tracheal bifurcation in buffaloes and 5-7 cm in goats. This tracheal bronchus supplies air to the cranial lobe of the right lung. It further divides into a cranial segmental bronchus, which ventilates the cranial part of the cranial lobe, and a caudal segmental bronchus, which ventilates the caudal part of the cranial lobe. The trachea then continues downward and bifurcates into the right and left principal bronchi, each entering the corresponding lungs through the pulmonary hilus. The right principal bronchus then branches into the middle, accessory, and caudal bronchi. The middle lobar bronchus supplies the middle lobe through dorsal and ventral segmental bronchi. The accessory lobar bronchus is located ventrally just after the origin of the middle bronchus and supplies the accessory lobe through dorsal and ventral segmental bronchi. The right principal bronchus then continues as the caudal lobar bronchus, which supplies the caudal lobe through dorsal, ventral, lateral, and medial segmental bronchi. The left principal bronchus enters the left lung and gives off the left cranial lobar bronchus, which supplies the left cranial lobe. It is divided into the cranial segmental bronchus, which supplies the cranial part of the cranial lobe, and the lateral segmental bronchus, which supplies the caudal part of the cranial lobe. The continuation of the left principal bronchus acts as the left caudal lobar bronchus, supplying the left caudal lobe through dorsal, ventral, lateral, and medial segmental bronchi.

The bronchial tree of camel (Fig.15)

Just before the trachea bifurcates, it gives off a tracheobronchial bronchus (Bronchus trachealis) that supplies the right cranial lobe. Within this lobe, the bronchus further divides into cranial and caudal segmental bronchi. When the trachea reaches the level of the pulmonary hilum, it divides into the right and left principal bronchi. The right principal bronchus enters the hilus of the right lung and gives off an accessory bronchus that ventilates the accessory lobe through cranial and caudal segmental bronchi. Then, the principal bronchus continues as the right caudal lobar bronchus, ventilating the right caudal lobe through dorsal, ventral, lateral, and medial segmental bronchi, which further subdivide into subsegmental bronchi. The left principal bronchus enters the hilus of the left lung and extends caudolateraly for about 3-5 cm. At this point, it branches off the

left cranial lobar bronchus to ventilate the left cranial lobe, after which it divides into cranial and caudal segmental bronchi. The left principal bronchus then continues as the left caudal lobar bronchus, ventilating the left caudal lobe via dorsal, ventral, lateral, and medial segmental bronchi, which further divide into subsegmental bronchi, and so on.

The bronchial tree of dog (Figs. 16A & 16B)

On examining the dog's lung tissue, we observed that the trachea was divided into the right and left principal bronchi. The right principal bronchus extended approximately 3 to 4 cm into the lung Hilus, where it separated the right cranial lobar bronchus from its lateral side. About 5 cm further down, it gave rise to the right middle bronchus from its dorsolateral aspect. Continuing caudally, it then gave off the accessory lobar bronchus from its ventromedial aspect and proceeded as the right caudal lobar bronchus. This lobar bronchus further divided into dorsal, lateral, medial, and ventral segmental bronchi (Fig. 16 A). In two of the dog's lungs examined, we found that the right cranial and middle lobar bronchi shared a common origin from the right principal bronchus (Fig. 16 B/ 4). The left principal bronchus entered the left lung and, after about 7 cm, gave rise to the left cranial lobar bronchus from its lateral aspect. The left cranial lobar bronchus then divided into cranial and caudal segmental bronchi. The cranial segmental bronchus supplied the cranial part of the cranial lobe, while the caudal segmental bronchus supplied the caudal part of the cranial lobe. The left principal bronchus continued caudally as the left caudal lobar bronchus, which further divided into dorsal, lateral, medial, and ventral segmental bronchi.

Electronic Learning Module
(Please, click here http://vetmed-academy.com
(Trachea and Bronchial tree)

TITLE

Descriptive Anatomy of the Trachea and Domestic Animal's Bronchial Trees.

WELCOME

Welcome to our regular online E-learning platform. Throughout this meeting we will present anatomical analysis of the trachea and bronchial tree of donkeys compared to other domestic animals (buffalo, goat, camel and dog).

This module aims to provide comprehensive information about animal anatomy, with a specific focus on the respiratory system. It will include formative assessments in the form of quizzes to monitor progress, gather student feedback, and ensure satisfaction. Additionally, a summative assessment will be conducted at the end to measure overall performance and understanding.

INSTRUCTIONS

To fully benefit from the course, it is vital that you;

- Take part in the hands-on labs conducting in the dissecting hall to develop your practical skills.
- Peruse the carefully curated specimens on display in the Department's museum.
- Access the Department's notes, online resources, and library materials for enhancing your academic performance.
- Contact the course consultant, in case you require additional support, via the different channels, including face-to-face meetings and other modes of communication (Facebook, WhatsApp, Telegram, Skype, …)

LEARNING OBJECTIVES

Upon successful completion of this module, students will be able to:

- Identify the anatomical morphology of the donkey's trachea.
- Explain the overall appearance of the bronchial tree.
- Differentiate between the bronchial trees of domestic animals.
- Verify the key points of differentiation among the bronchial trees of domestic animals.

CONTENTS

The module's content will be presented in the following format:

A. Text

Trachea and comparative bronchial tree comparative

B. Active learning

C. Windows media video

D. PRACTICE ACTIVITIES

Under the supervision of your consultant, and with the aid of your practical notes, carefully dissect the trachea of the donkey and examine its bronchial tree. Following this, engage in a detailed discussion with your peers about the distinguishing characteristics of the bronchial trees of the buffalo, goat, camel, and dog.

E. WEB-BASED LEARNING TUTORIAL

1- https://vetmed-academy.com/moodle/

2- Respiratory System The University of Nottingham - ppt video online download

3- https://guides.library.upenn.edu/VetStudy-Anatomy
4- https://www.youtube.com/watch?v=-S25qRjCwWA
5- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8653125/
6- Veterinary Anatomy Site Map

F. ASSESSMENTS

Formative Assessment
Summative Assessment

G. SUMMARY

The trachea of a donkey is a long and flexible tube composed of 49-51 C-shaped, dorsally open hyaline cartilages. It runs from the cricoid cartilage of the larynx to the base of the lung, around the level of the 5th rib, where it divides into the right and left principal bronchi. The trachea has a cervical part, consisting of about 36-37 hyaline cartilages, and a thoracic part, with about 13-14 hyaline cartilages. Following the tracheal division, the bronchial tree begins, with each principal bronchus entering the corresponding lung and giving rise to lobar bronchi named after the lobes they serve. In domestic animals, the right principal bronchus gives four lobar bronchi (cranial, accessory, middle, and caudal). The right middle lobar bronchus is typically absent in camels and donkeys, except in 40% of examined donkey lungs. The left principal bronchus gives two lobar bronchi (cranial and caudal), except in 40% of examined donkey lungs, where the left principal bronchus produces the middle lobar bronchus. The bronchial tree of camels is more closely related to those of buffalo and goats. In these animals, the trachea gives tracheal bronchus, which ventilates the right cranial lobe.

H. CONTACT US

Consultants to contact

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Meeting time: Monday (10 am – 1pm)	Tuesday (9- 12)

Contact us for questions, comments or feedback

I. DATA SOURCES:

- Self-Research (1ry. Data)
- Modified previous data (2ry. Data)
- Web sites' links.

E-learning survey

A specialist designed, revised and reported a survey questionnaire, that given to 45 first-grade students in the 2023-2024 academic year (Special VDP, and PA programs). The students first studied the anatomy of the respiratory system using traditional teaching methods and then were introduced to blended learning through Vetmed-academy.com as a model. The data

was tabulated, statistically analyzed, and summarized.

Upon analyzing the data gathered from post-studies of e-learning modules, the survey results were overwhelmingly positive in regards to course expectations, structure, content, quizzing, timing, e-learning pace, navigation, multimedia, and interactivity. Nevertheless, the responses regarding Information and Communication Technology (ICT) and internet services issues were less favorable. It is also notable that the majority of students expressed a preference for blended learning, which involves a combination of face-to-face and electronic learning

Figures

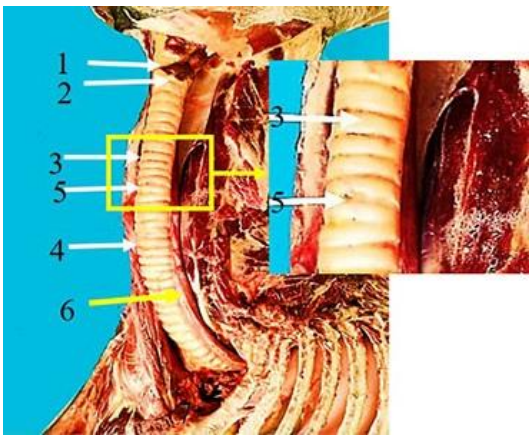


Fig. 1: Photograph of the donkey's cervical trachea:
1- Cricoid cartilage, 2- Thyroid gland, 3- 10th. Tracheal rings, 4- 20th. Tracheal cartilage, 5- Annular ligament, 6- Esophagus, and 7- 1st rib

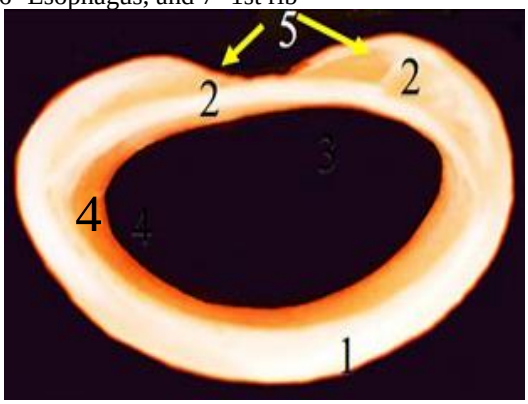


Fig.2: Photograph of a cross section in a tracheal ring of the donkey
1- C-shape tracheal ring, 2- Tracheal muscle, 3- Paries membranaceus 4- Tracheal mucosa, and 5- Free ends of tracheal ring (arrows).

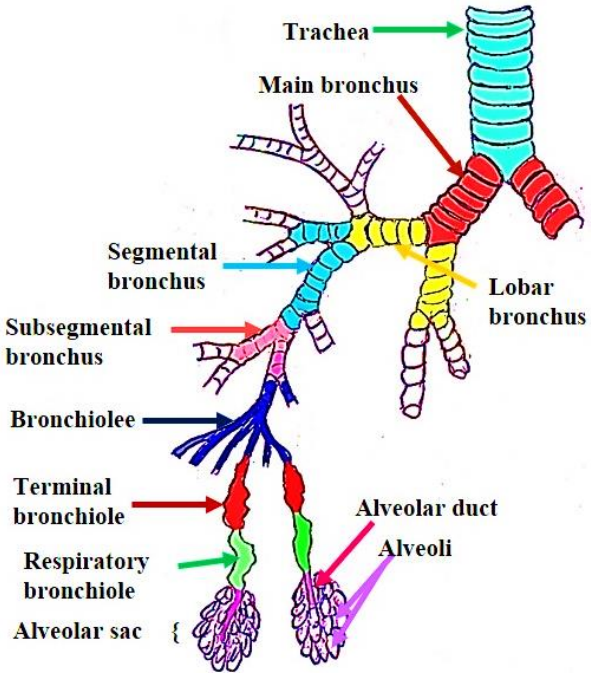


Fig. 3: Diagrammatic illustration showing the general scheme of the bronchial tree.

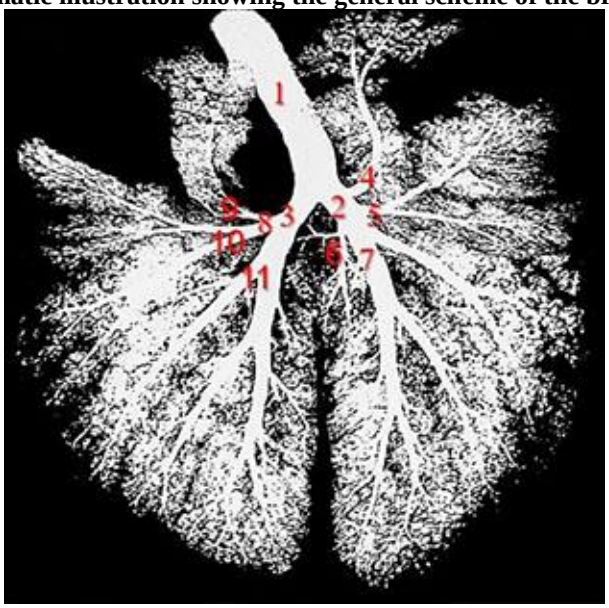


Fig. 4: A donkey's lungs radiograph (dorso-ventral view) showing the bronchial tree pattern, labeled accordingly;

1. Trachea, 2. Right principal bronchi, 3. Left principal bronchi, 4. Cranial segmental of right cranial lobar bronchus, 5. Caudal segmental of right cranial lobar bronchus, 6. Accessory lobar bronchus, 7. Right caudal lobar bronchus, 8. Left cranial lobar bronchus, 9. Cranial segmental of left lobar bronchus, 10. Caudal segmental of left lobar bronchus, 11. Left caudal lobar bronchus

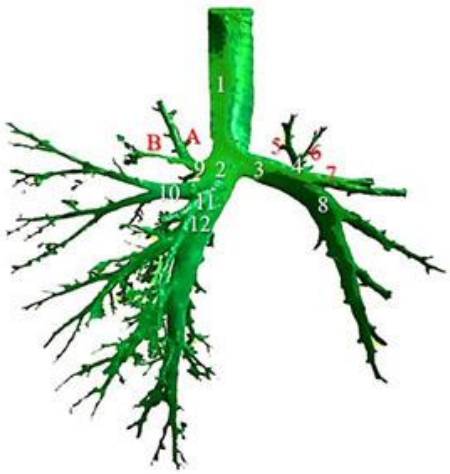


Fig. 5: A corrosion cast showed a different bronchial tree pattern of a donkey (only in two cases) photographed from ventral aspect.
1. Trachea, 2. Right principal bronchi, 3. Left principal bronchi, 4. Left cranial lobar bronchus, 5. Cranial segmental of the left cranial lobar bronchus ,6. Caudal segmental of the left cranial lobar bronchus, 7. Suggested left middle lobar bronchus, 8. Left caudal lobar bronchus, 9. Right cranial lobar bronchus
A. Cranial segmental of right cranial lobar bronchus, B. Caudal segmental of right cranial lobar bronchus, 10. Suggested right middle lobar bronchus, 11. Accessory lobar bronchus, 12. Right caudal lobar bronchus.

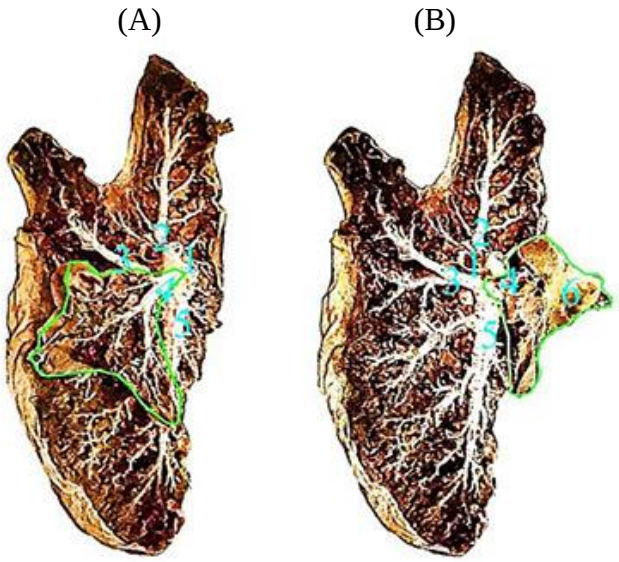


Fig. 6 (A&B): A ventral view photograph of a donkey's right lung after being dissected to display the pattern of its bronchial tree.
In the picture, (B) the accessory lobe reflected dorsally.
1. Right principal bronchus, 2. Right cranial lobar bronchus, 3. Suggested right middle lobar bronchus, 4. Accessory lobar bronchus, 5. Right caudal lobar bronchus, 6. Accessory lobe (reflected)

Fig. 7: a photograph of the bronchial tree pattern of a left lung from a donkey, which has been blunt-dissected. The view of the lung shown is from the ventral side.
1.Left principal bronchus, 2. Left cranial lobar bronchus, 3. Suggested Left middle lobar bronchus, 4. Left caudal lobar bronchus.

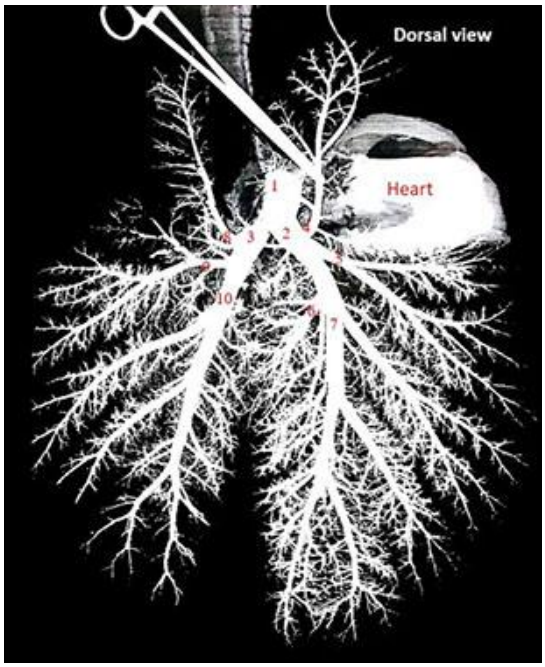
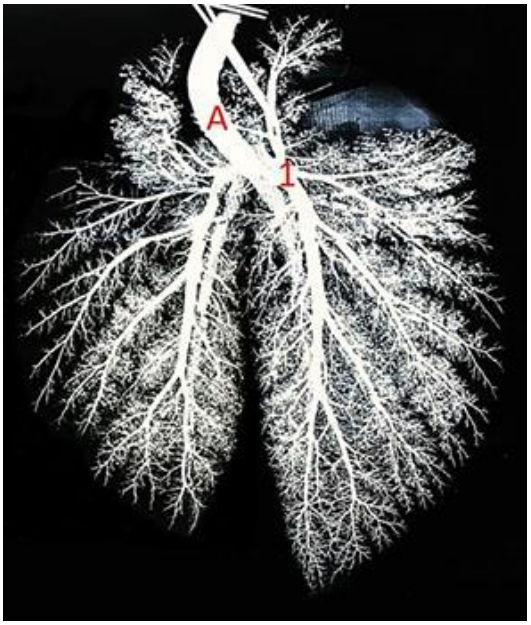


Fig. 8: A labeled X-ray image of a donkey's pulmonary trunk showing the distribution pattern of the pulmonary artery, indicating different branches of the artery. 1- Pulmonary trunk, 2- Right pulmonary artery, 3- Left pulmonary artery, 4- Right cranial lobar branch, 5- Right middle lobar branch, 6- Accessory lobar branch, 7- Right caudal lobar branch, 8- Left cranial lobar branch, 9- Left middle lo**bar** branch, 10- Left caudal lobar branch.



Figs. 9: Radiograph of the donkey's pulmonary trunk (1) and bronchial tree (A) exhibit a similar branching pattern., A: Trachea, 1: Pulmonary trunk

Figs. 10: A photograph displayed a visualization of a donkey's lungs after being injected via the pulmonary trunk with red-colored gum milk latex, revealing its distribution pattern in relation to the bronchial tree. The labeled parts are:
Trachea (A), Pulmonary trunk (1), Right pulmonary artery (2), Left pulmonary artery (3), Right cranial lobar branch (4), Right middle lobar branch (5), Accessory lobar branch (6), Right caudal lobar branch (7), Left cranial lobar branch (8), Left middle lobar branch (9), and Left caudal lobar branch (10).

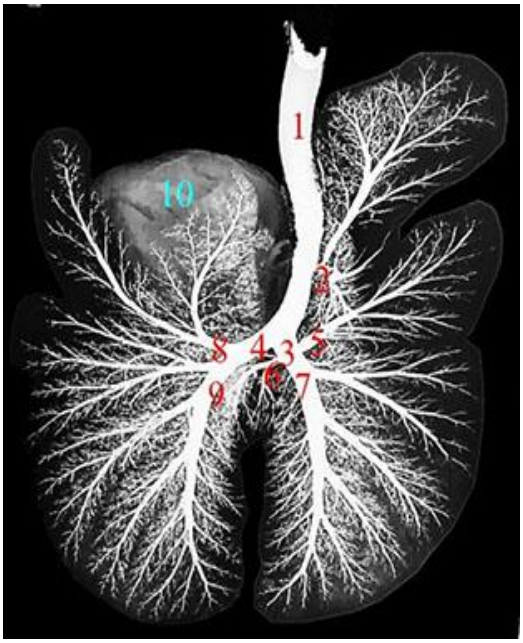


Fig. 11: Radiograph of a buffalo's lungs (dorso-ventral view), showing bronchial tree pattern.

1: Trachea, 2: Tracheal bronchus, 3: Right principal bronchus, 4: Left principal bronchus, 5: Right middle lobar bronchus, 6: Right accessory lobar bronchus, 7: Right caudal lobar bronchus, 8: left cranial lobar bronchus, 9: Left caudal lobar bronchus, and 10: Heart.

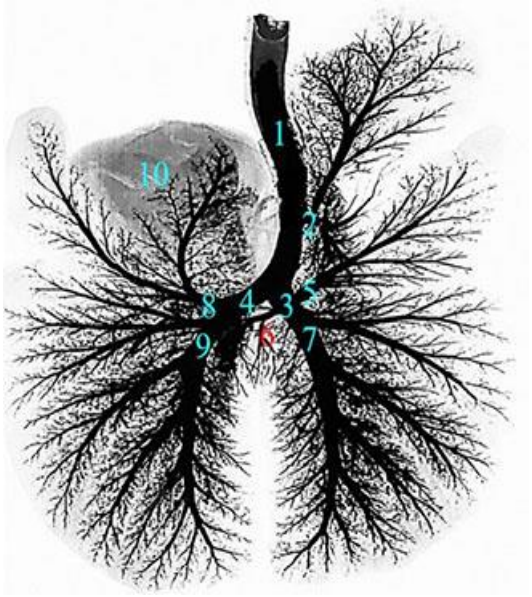


Fig. 12: A radiographic image of the lungs of a buffalo (dorsoventral view), displaying a clear pattern of the bronchial tree. The image appears to be positive

1: Trachea, 2: Tracheal bronchus, 3: Right principal bronchus, 4: Left principal bronchus, 5: Right middle lobar bronchus, 6: Right accessory lobar bronchus, 7: Right caudal lobar bronchus, 8: left cranial lobar bronchus, 9: Left caudal lobar bronchus, and 10: Heart.

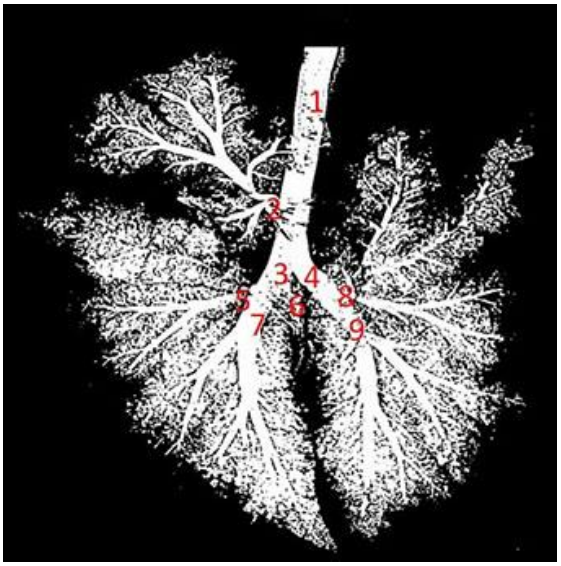


Fig. 13: A radiograph image of a goat's lungs, viewed from a ventro-dorsal angle. The image shows the pattern of the goat's bronchial tree.
1: Trachea, 2: Tracheal bronchus, 3: Right principal bronchus, 4: Left principal bronchus, 5: Right middle lobar bronchus, 6: Right accessory lobar bronchus, 7: Right caudal lobar bronchus, 8: left cranial lobar bronchus, and 9: Left caudal lobar bronchus.

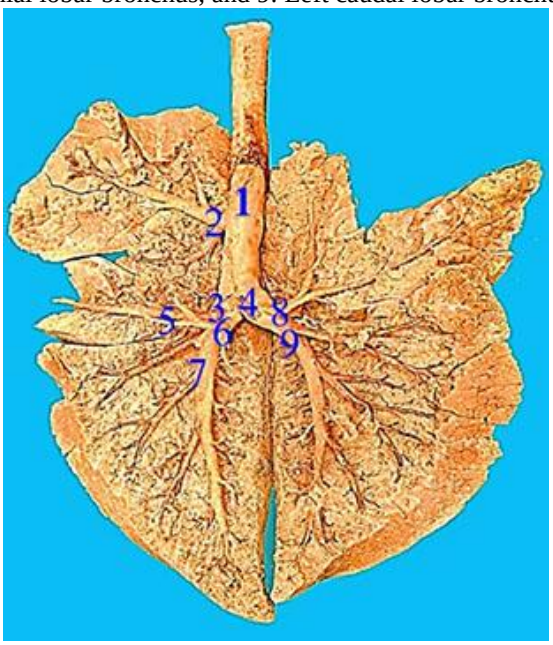


Fig. 14: Photograph of the bronchial tree of a Plunt-dissected goat's lungs after injecting epoxy 150 cast material colored with acrylic paint, displayed in a ventral view
1: Trachea, 2: Tracheal bronchus, 3: Right principal bronchus, 4: Left principal bronchus, 5: Right middle lobar bronchus, 6: Right accessory lobar bronchus, 7: Right caudal lobar bronchus, 8: left cranial lobar bronchus, and 9: Left caudal lobar bronchus.

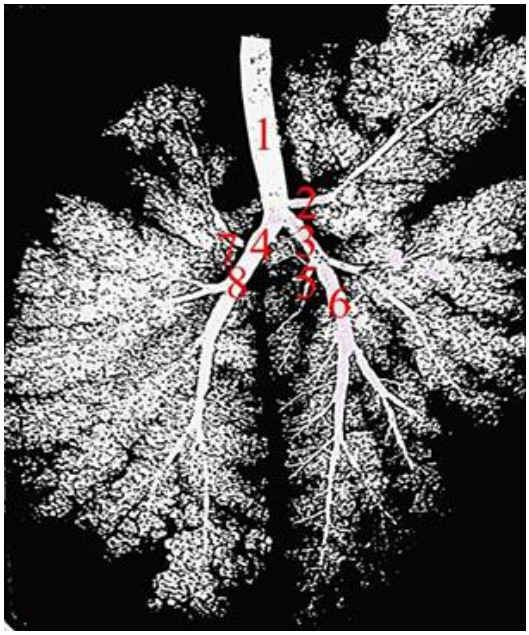


Fig. 15: Radiograph of the camel' lungs (dorso-ventral view), showing bronchial tree pattern.
1: Trachea, 2: Tracheal bronchus, 3: Right principal bronchus, 4: Left principal bronchus, 5: Right accessory lobar bronchus, 6: Right caudal lobar bronchus, 7: left cranial lobar bronchus, and 8: Left caudal lobar bronchus.

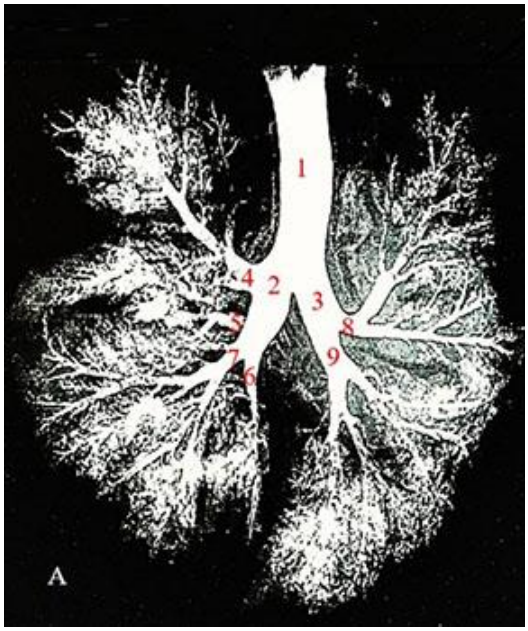


Fig. 16A: Radiograph of the dog's lungs (ventrolateral view) displaying its bronchial tree pattern. 1: Trachea, 2: Right principal bronchus, 3: Left principal bronchus, 4: Right cranial lobar bronchus, 5: Middle lobar bronchus, 6: Accessory lobar bronchus, 7: Right caudal lobar bronchus, 8: Left cranial lobar bronchus, and 9: Left caudal lobar bronchus.

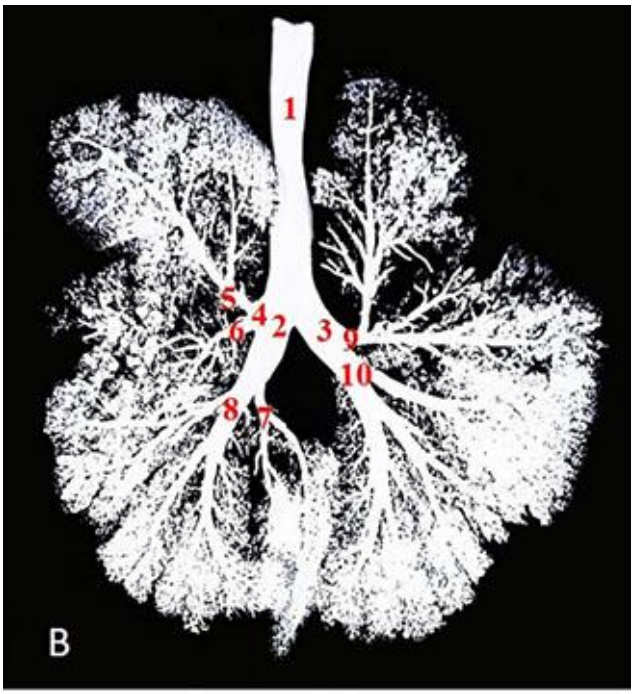


Fig. 16B: Radiograph of the dog's lungs (ventrolateral view) displaying its bronchial tree pattern.

1. Trachea, 2. Right principal bronchus, 3. Left principal bronchus, 4. Common origin of the Right cranial and middle lobar bronchi, 5. Right cranial lobar bronchus 6. Right middle lobar bronchus, 7. Accessory lobar bronchus, 8. Right caudal lobar bronchus,
9. Left cranial lobar bronchus, and 10. Left caudal lobar bronchus.

Discussion

The present study examines the structure of the trachea in the donkey and the bronchial tree of domestic animals and aligns with previous research by ***Hare (1975), Nickel et al. (1979), Dyce et al. (2018), Singh et al. (2006),*** and ***Konig et al. (2007).*** The tracheal rings in donkeys are similar to those found in horses, and ox ***(Nickel et al., 1979),*** camels ***(Hussein & Zahra, 2016),*** and goats ***(Yousif & Dawood, 2019).*** However, ***Dabanoğlu et al. (2001)*** observed circular tracheal cartilages in dogs. Unlike sheep ***(Al-Umeri, 2015)***, goats ***(Nickel et al., 1979),*** and camels ***(Hussein & Zahra, 2016),*** the tracheal cartilages in donkeys do not have overlapping free edges.

The tracheal tube's elastic nature allows for slight expansion during deep inspiration, while the rigid rings prevent tracheal collapse. The annular ligament between the rings provides great flexibility during head and neck movement ***(Fox Run Equine Center, 2016).***

The bronchial tree in all domestic animals begins immediately after the tracheal bifurcation, forming the right and left principal bronchi, which then branch into lobar bronchi. These bronchi are named according to the lung lobes they ventilate. Studies on equines by ***Nickle et al. (1979)*** and ***Smith et al. (2015)*** found that the right principal bronchus branched into the right cranial, accessory, and right caudal lobar bronchi, which was also observed in 60% of the studied donkey cases. However, in the remaining 40% of the donkey cases, the right principal bronchus branched into an additional middle lobar bronchus, as mentioned by ***Menaka et al. (2015)*** in equines. On the other hand, the left principal bronchus branched into the left cranial and left caudal lobar bronchi in 60% of the studied cases, as observed in previous studies on equines by ***Hare (1975), Nickle et al. (1979)***, and ***Menaka et al. (2015).*** However, 40% of the studied donkey lungs showed an additional left middle lobar bronchus.

In the current study, it was observed that the pulmonary trunk of a donkey divides into the right and left pulmonary arteries just before the tracheal bifurcation. Each of these arteries enters the corresponding lung and follows the ramification of the bronchial tree. This observation aligns with previous studies conducted on domestic animals such ***as Guzsal (1952), Wilkens and Munster (1975), Nakakuki (2000)*** on horses, and ***Osman and Ibrahim (1981)*** on donkeys. The study also noted that the right pulmonary artery divides into four branches: the right cranial lobar artery, the right middle lobar artery, the accessory lobar artery, and the right caudal lobar artery. This finding is consistent with the observations of ***Osman and Ibrahim (1981)*** in donkeys and ***Nakakuki (2000)*** in horses. On the other hand, the left pulmonary artery divides into two branches, namely the left cranial lobar artery and the left caudal lobar artery, which also agrees with the previous study conducted by ***Osman and Ibrahim (1981)*** on donkeys.

There are notable challenges confronting higher education in Egypt ***(Ghada, 2016)*** and in many other countries, particularly those with limited resources or grappling with national or regional crises ***(Fatma abdallah et al, 2020).*** These challenges impede the educational process, leading to a cycle of unsustainability across various social and economic aspects. Numerous studies have been undertaken to discover scientific and practical solutions to these education challenges. Consequently, many countries have begun to explore non-traditional approaches to address these deficiencies and enhance the educational process to attain desired educational outcomes and surmount the challenges.

The current study, in agreement with ***Markus (2008),***

defines E-learning as the process of learning that involves interaction with digitally delivered content, network-based services, and tutoring support. This can occur using computers from a distance or in a face-to-face classroom setting (computer-assisted learning). ***Markus (2008)*** also emphasizes that E-learning represents a departure from traditional education or training methods, as it is based on personalized, flexible, individual, self-organized, and collaborative learning, utilizing a community of learners, teachers, facilitators, and experts, all mediated by ICT.

The current study is consistent with ***Dakroury (2021)*** and ***Fatma Abdallah et al. (2020)*** in highlighting the various advantages of E-learning. E-learning offers increased accessibility to education for learners at any time and place, cost reduction, flexibility in scheduling, empowerment of learners, competitive advantage through fast and effective learning, personalized learning opportunities, and expanded course offerings. Additionally, ***Singh (2023)*** pointed out that universities are increasingly embracing E-learning due to its cost-saving benefits compared to traditional learning methods.

The most recent research confirms earlier findings that online education (E-learning) is a crucial tool for self-directed and self-organized learning. It accommodates students with diverse skills and capabilities and is essential for the long-term retention of knowledge. According to **Barbara *Alessandrini* et al. (2008),** E-learning is a powerful and valuable extension of traditional educational initiatives. ***Allison (2016)*** notes that E-learning courses offer a flexible and versatile learning system that allows individual learners and organizations to tailor their training to their specific needs. Additionally, ***Gupta (2017)*** highlights the growing popularity and appreciation of E-learning among students worldwide. However, ***Fatma Abdallah et al. (2020)*** have shown that despite the numerous benefits of long-distance learning and E-learning, such as increased accessibility and flexibility, there are still challenges, including the lack of face-to-face interactions and the requirement for a reliable internet connection and advanced IT technology. ***Radović-Marković (2010)*** emphasizes the close relationship between the development of online education and advances in Internet technologies. Furthermore, ***Eastmond (2000), Sehrt (2003), and Evans (2005)*** have stressed the importance of active student participation in interactive learning environments like E-learning, which may be uncommon in developing countries. In a statistical study, ***El Gamal and Abd El Aziz (2012)*** reported that despite Egypt being a developing country with a high illiteracy rate, the majority of higher education students access the

internet from their homes daily and are frequent technology users. ***Callum (2021)*** points out that technology has significantly enhanced higher education by catering to the unique learning needs and styles of students. Innovations such as learning management systems (LMS), adaptive learning software, and video conferencing have transformed the way and places where students study.

The COVID-19 pandemic prompted the closure of educational institutions worldwide, resulting in a surge in the E-learning sector ***(Sivankalai, 2021).*** During lockdown periods in many countries, E-learning proved to be invaluable in preventing educational loss for students, as highlighted by ***Bajaj (2020).*** The current study aligns with ***Callum (2021)*** and ***Singh (2023)*** in emphasizing the importance of understanding hybrid and blended learning and adapting these frameworks to achieve learning outcomes as reopening guidelines for higher education institutions continue to evolve. ***Singh (2023)*** defines blended learning as the seamless integration of traditional class instruction with digital, online learning. Similarly, ***Callum (2021)*** and ***Singh (2023)*** articulate that Hybrid learning refers to an educational approach that combines traditional classroom teaching with online or distance learning techniques, such as experiential learning and remote course delivery.

Callum (2021) emphasized that the objective of hybrid learning is to integrate a well-balanced mix of teaching strategies to effectively deliver content while addressing the diverse learning needs of students. The supplementary learning strategies are intended to complement traditional face-to-face instruction rather than replace it. For instance, in a class that convenes twice a week, a hybrid learning instructor could plan for an in-person lecture on one day and a hands-on lab or online assignment on the other. The current study aligns with ***Fatma Abdallah et al. (2020)*** observation that e-learning modules generally follow a well-structured format. This typically includes an engaging introduction, a task or final project, a set of questions or steps, online study resources, performance assessment, and a conclusion that encourages self-reflection on the lessons learned. This framework is based on the findings of ***McCoy (2005), Salsovic (2007),*** and ***Calder (2011),*** who have extensively detailed the essential components necessary for designing a successful e-learning program. In our study, similar elements were utilized in the development of the e-learning modules.

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Ethical of approval: This study follows the ethics guidelines of the Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt. (Ethics approval number (19/ 2020))

References:

Allison, L. (2016): 4 Tips for Making Your E-Learning Course Content Mobile Friendly.; Getting Started with Multi-Device E-Learning.; Why Rise 360 Is a Kick-Butt Multiservice Authoring App. Learning Heroes

Al-Umeri, S. K. W. (2015): Grossly and microscopic study of the trachea and bronchial tree in the local sheep *(Ovis aris). Bas J Vet Res*, *14*, 145-155.

Bajaj, S. (2020): E-learning: a framework of technology reliant education. *New Paradigm in Business & Education*, 181.

Barbara Alessandrini, Silvia D'Albenzio, Monica Turrini, Lejla Valerii (2008). Experience with usability evaluation of e-learning systems. https://www.izs.

Calder, N. (2011): "Processing mathematics through digital technologies". Rotterdam, The Netherlands: Sense.

Callum, R. (2021): Hybrid and blended learning in higher education. ***https://elearningindustry.com/blended-learning-ultimately-best-corporate-training***

D'Albenzio, S. & Alessandrini, B. (2010): Modules for E Learning Training Courses Und er the Programme "Better Training for Safer Food " Istituto G. Caporale - Teramo Guido Cernuto

Dabanoğlu, I., Öcal, M. K., & Kara, M. E. (2001): "A quantitative study on the trachea of the dog". *Anatomia, histologia, embryologia*, *30*(1), 57-59.

Dakroury, Y. H. (2021): Egyptian E-Learning University: Case Study. International Journal of Internet Education. http://ijie.journals.ekb.eg/

Dyce, Sack, and Wensing's (2018): Textbook of Veterinary Anatomy, 5th Edition. s://www.slideshare.net › borzupista › Dyce-sack-and-wensing-s-text book [PDF] by Baljit Singh, BVSc & AH, M.V. Sc, PhD, FAAA, 3M National Teaching Fellow

Eastmond, D. (2000): 'Educational technology research and development', Realizing the Promise of Distance Education in Low Technology Countries, Vol. 48, No. 2, pp.100–111.

El Gamal, S. and **Abd El Aziz, R. (2012):** 'Improving higher education in Egypt through e-learning programs: HE students and senior academics perspective',

Elnady, F., (2016): The Elnady Technique: An innovative, new method for tissue preservation, ALTEX 33 (3),

Fox Run Equine Center (2016): Fox Run Equine Center - Veterinarian in Apollo, PA, US. https://www.foxrunequine.com

Evans, R. (2005): Explaining Low Learner Participation during

Interactive Television Instruction in a Developing Country Context, PhD Dissertation, University of Pretoria [Online], Available at: http://upetd.up.ac.za/thesis/submitted/etd-02282005-081708/unrestricted/00front.pdf (Accessed: 18 January, 2013).

Fatma Abdallah. Elsaid, Imam H., and Abuzeid S. M. (2020): "The anatomy of the nasal cavity of the donkey (a model for electronic learning modules) ". SCVMJ XXV (1), 83-103.

Ghada Barsom (2016): Egypt's Higher Education; Challenges and Keys to Improvement. In the fourth series of "Faculty at the Forefront, held at The American University in Cairo (AUC).

Gheorghe M. Constantinescu (2018): Illustrated Veterinary Anatomical Nomenclature, 4th Edition. 4th. ed. VETBOOKS-TELEGRAM CHANNEL

Gupta, M ; Marsden ,S; Oluka, T and Sharma ,R. (2017): "Lessons Learned From Implementing E-Learning for the Education of Health Professionals in Resource-Constrained Countries." Electronic Journal of e-learning **15**(2): 144-155.

Guzsal, R.S. (1952): "The topography of the blood vessels and of the bronchial tree of domestic animals", Mag. Allatcr. Lapja, 13; l89 _222.

Hare, W. C (1975): "Respiratory System" In The Anatomy of the Domestic Animals. 5th ed. Vol. 1, 2. ed. By R. Getty, W. B. Saunders Company, Pp: 511-514, 518-523, 926-933, 1290-1294, 1567-1572.

https://www.foxrunequine.com/contact

Hussein, A. J., & Zahra, I. A. A. (2016): "Morphological, histological and histochemical study of trachea of one hump camel (Camelus dromedaries) in south of Iraq". *Original article*, 19-25. Int. J. Innovation in Education, Vol. 1, No. 4, pp.335–361.

König, H. E., Bragulla, H., & Hans-Georg, H. G. (2007): *Veterinary anatomy of domestic mammals: textbook and colour atlas*. Schattauer Verlag.

Lynda, J. T. (2018): Preservation of Animal Cadavers with a Formaldehyde-free Solution for Gross Anatomy. Article *in* Journal of Morphological Sciences

Markus, B. (2008): Thinking about e-Learning. In *Proceedings FIG International Workshop. Sharing Good Practices: E-learning in Surveying, Geo-information Sciences and Land Administration* (pp. 11-13).

McCoy, L. P. (2005): Internet Web Quest: A context for mathematics process skills. *Technology-supported mathematics learning environments: 67th Yearbook*, 189-201.

Menaka, R., Thanvi, P., & Joshi, H. (2015): "Luminal corrosion cast of tracheo-bronchial tree of equine lung". *Vet. Res. Int*, *3*(3), 68-70.

Naglaa A. Gomaa, Alaa E. Ghazy and Ayman S. Atiba, (2015): Effect of repeated intravenous administration of xylazine on sedation, analgesia and ECG parameters in donkeys (Equus Asinus). *Assiut Veterinary Medical Journal*, *61*(147), 124-130,

Nakakuki, S. (2000): "Distribution of the pulmonary artery and vein in the horse lung".

Nickel, R.; Schummer, A.; Seiferle, E., & Sack, W. O. (1979): The viscera of the domestic mammals (Vol. 2). P. Parey.

Nitin S. (2023): Higher Education. https://www.amazon.in/Higher-Education-Textbooks.

Nomina Anatomica Veterinaria (2017): SIXTH EDITION, prepared by the International Committee on Veterinary Gross Anatomical Nomenclature (I.C.V.G.A.N.), Published by the Editorial Committee Hanover (Germany), Ghent (Belgium), Columbia, MO (U.S.A.), Rio de Janeiro (Brazil) With permission of the World Association of Veterinary Anatomists (W.A.V.A.)

Osman, F., & Ibrahim, R. (1981): Macro. "Morphological studies on the pulmonary trunk of the donkey (Equus Asinus)". *The Egyptian Journal of Anatomy*, *4*(1), 1-8.

Radović-Marković, M. (2010): Advantages and disadvantages of e-learning in comparison to traditional forms of learning. *Annals of the University of Petroşani, Economics*, *10*(2), 289-298.

Salsovic, A. (2007): Integrating Technology into the Developmental Mathematics Classroom: A Web Quest. *NADE Digest*, *3*(1), 21-25.

Sehrt, M. (2003): 'UN Chronicle Online', E-Learning in the Developing Countries – Digital Divide into Digital Opportunities, Vol. 4, No. 3 [Online], Available at: http://www.un.org/Pubs/chronicle/2003/issue4/0403p45.asp (Accessed: 22 January, 2013).

Shakeel et al. (2023): eLearning Acceptance and Adoption Challenges in Higher Education. *Sustainability*, *15*(7), 6190; https://doi.org/10.3390/su15076190

***Shakeel,* A., S., Mohd Noor, A. S., Alwan, A. A., Gulzar, Y., Khan, W. Z., & Reegu, F. A.** (2023): E-Learning acceptance and adoption challenges in Higher Education. *Sustainability*, *15*(7), 6190

Singh, A., Singh, G. and Nagpal, S.K. (2006): "Broncho-pulmonary tree and segments of the lungs of buffalo calves". Haryana Vet. 45: 29-34.

Singh, Aman Kumar (2023): Blended Learning Vs. Traditional Learning: A Detailed Overview of the Two Approaches.

https://elearningindustry.com/blended-learning-vs-traditional-learning-a-detailed-overview-of-the-two-approaches#:~:text=Traditional%20learning%2C%20often

Sivankalai, S. (2021): Academic libraries support e-learning and lifelong learning: A case study. *Library Philosophy and Practice (e-journal)*, *8*(18), 1-18.

Smith, B. L., Aguilera-Tejero, E., Tyler, W. S., Jones, J. H., Hornof, W. J., & Pascoe, J. R. (2015): "Endoscopies anatomy and map of the equine bronchial tree". *Equine veterinary journal*, *26*(4), 283-290.

TechSmith Camtasia (2019): Instantly Smooths Out Audio and Cursor Path in Newest Release. www.techsmith.com › video-editor

Veterinaria, N. A. (2017). Nomina anatomica veterinária. *International Committee On Veterinary Gross Anatomical Nomenclature. 6th ed. Hannover*, 73-147.

Wilkens, H. and Munster, W. (1975): Nickel, E., Schummer. Und Seifrele,

Yousif, N. H., & Dawood, M. S. (2019): "Morphometric Comparative Anatomical Study of Lower Respiratory Tract between Sheep (Ovis aris) And Goat (Caprus hircus) in Baghdad provence". *Kufa Journal for Veterinary Medical Sciences*, *10*(2).

دراسة تشريحية مقارنة للمجرى الهوائي التنفسي السفلي في الحيوانات المستأنسة ، مع التشريح الوصفي للقصبة الهوائية (الرغام) للحمير (نموذج لوحدة تعلم اليكتروني)

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الملخص

- واجه التعليم العالي المصري، كما هو الحال في العديد من البلدان الأخرى، العديد من التحديات، تمثلت في الزيادة الملحوظة في أعداد الطلاب، وعدم كفاية قدرات تطوير العملية التعليمية، وارتفاع الرسوم في الجامعات الخاصة، وأوقات الأزمات الوطنية والدولية، مثل جائحة كوفيد-19

- تم اعتماد التعلم الإلكتروني على نطاق واسع من قبل المؤسسات التعليمية على مستوى العالم كحل موثوق للتغلب على تحديات التعليم ، وكان هذا الأمر حاسما بشكل خاص في أوقات الأزمات.

- تم اختيار تشريح الجهاز التنفسي السفلي للسلالات المحلية للحيوانات المستأنسة ، مثل الحمير والجاموس والماعز والجمال ، بما في ذلك الشعب الهوائية وأجزاء الجهاز التنفسي ، كأساس تشريحي لإعداد وحدات تعلم إليكتروني.

تم إجراء الدراسة التشريحية باستخدام تقنيات مختلفة مثل التشريح العياني والتصوير الشعاعي ونمذجة القوالب وإعداد العينات المتحفية.

- لإعداد وحدات التعلم الإلكتروني ، تم استخدام الوسائط الإلكترونية ونظام إدارة التعلم (LMS) ومنصة استضافة (http://vetmed-academy.com) واستراتيجيات التعلم المختلفة مع عمل مسح تقييمي بعد إستخدام نماذج التعلم.

- أوضحت الدراسة تكون مجرى الهواء من القصبة الهوائية ، والشعب الهوائية الرئيسية ، والشعب الهوائية الفصية ، والشعب الهوائية المقطعية ، والشعب الهوائية الفرعية ، والقصيبات الهوائية ، والقصيبات الطرفية، و يتكون الجزء التنفسي من القصيبات التنفسية والقنوات السنخية والحويصلات الهوائية ، وكلها تلعب دورا مهما في عملية التنفس.

- كما أوضحت الدراسة وجود ارتباط بين التشعبات الهوائية الفصية وعدد فصوص الرئتان في الحيوانات المختلفة

- خلص الاستطلاع المطبق على وحدات التعلم الإلكتروني التي تم إعدادها وتقديمها للطلاب الحصول على بيانات تحليلية إيجابية للغاية فيما يتعلق بأهداف الوحدة ، والهيكل ، والمحتوى ، والاختبار ، والتوقيت ، ووتيرة التعلم الإلكتروني ، والتنقل ، والوسائط المتعددة ، والتفاعل. ومع ذلك، كانت الردود المتعلقة بقضايا تكنولوجيا المعلومات والاتصالات وخدمات الإنترنت أقل مواتاة.

- وقد أعرب غالبية الطلاب عن تفضيلهم للتعلم المدمج، والذي يتضمن مزيجا من التعلم وجها لوجه والتعلم الإلكتروني.